Liebe Group

2024

Annual Report

Carbon Demo Project

Project title:

Using living plant systems and modern farming methods to sequester soil organic carbon, reduce greenhouse gas emissions and improve soil fertility

Trial title:

Effect of soil amelioration and organic amendments on water use efficiency and soil carbon on sandy soils with multiple soil constraints.

Trial Location:

Charles Wass Property, West Coorow (29°58'01.3"S 115°59'51.7"E)

SOIL CRC

Department of Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

Date:

17/03/2025

Key messages

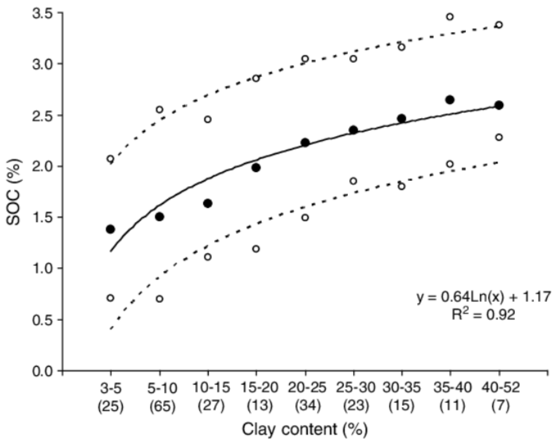
On a poor sand, with limited production history, adding clay and organic matter may increase the water holding capacity of the soil, in turn increasing plant health, biomass and yield.

Background

The west Coorow region is characterized by deep coarse sands and sandy loams, many of which have low water and nutrient holding capacity. The addition of clay has been shown to increase carbon storage capacity of the soil. Furthermore, increasing soil carbon provides an energy source for microbes, supplies & store nutrients, improve soil structure and increases water holding capacity.

The paddock chosen had no cropping or pasture history and is a deep yellow coarse sand. The site was covered with tussocky weeds and needed rejuvenating to bring back into production. Soil analyses of the site indicated a clay content of between 3-5%, organic carbon levels of 0.2% and a low nutrient status.

Two treatments of 80 t/ha and 60 t/ha of bentonite clay were added in strips and it is hypothesized that this will increase the clay content by around 2-4%. Figure 1 (below) shows that by increasing the clay content, the soil organic carbon holding capacity of the soil should increase in turn.



3 Influence of clay content on the range of soil organic carbon (SOC) values in a 10 ha area of a paddock under cereal–legume rotation in the central agricultural region of Western Australia. Solid circles represent the average SOC value for each clay content whilst open circles represent the upper and lower SOC values for each clay content. The numbers of samples within each clay content are shown in brackets (n = 220 in total). The soil contained no gravel

Figure 1. Influence of clay content on the range of soil organic carbon content values. Source: Hoyle FC, Baldock J, Murphy DV (2011). Rainfed Farming System

The ability of this soil to actually increase soil organic carbon, will depend on being able to maximise biomass production on this site. Chicken Manure was added as a treatment to provide an organic matter and nutrient boost, however maximizing crop water use efficiency will be key to achieving measurable increases. Figure 2 outlines the defining, limiting and decreasing factors of soil organic matter storage.

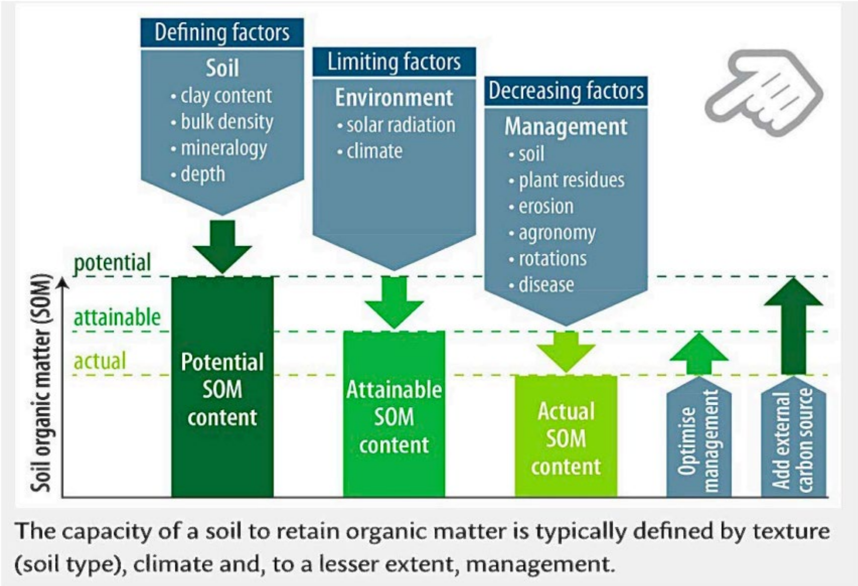


Figure 2. Capacity of a soil to retain organic matter. (Hoyle, F., Soil Organic Matter, a nexus for sustainability, rising to the challenge in WA agriculture, Soils West.)

The clay was added in 2022, with chicken manure spread in 2023. These amendments have been ploughed into the soil to around 30cm, using a one way 'plozza' plough during winter of 2023. The dry conditions experience at this site in 2023 meant that the site was not able to establish a crop. In 2024 wheat was sown. The aim is to establish as much biomass on the site as possible to maximise organic matter return to the site.

In 2024, the Liebe Group's trial site west of Coorow continued its focus on improving the productivity of deep yellow coarse sand with low organic carbon (0.2%) and nutrient levels. The project was started in 2022 in response to growing farmer interest in practices that improve nutrient recycling from organic sources and increase soil carbon. This interest is supported by research showing that increasing soil carbon provides an energy source for microbes, enhances nutrient storage, improves soil structure, and increases water-holding capacity (Hoyle & Murphy, 2018). Additionally, the potential for carbon credit units (ACCUs) to become a future income stream has drawn attention.

Table 1 – Description of the novel amendments utilised in this demonstration trial.

Novel soil amendments	Description
Bentonite Clay	A rare natural semi-granulated saponite clay with levels of calcite, dolomite, halite and quartz
Chicken Manure	A nutrient-rich poultry manure.

Methodology

Table 2: Trial 1 and 2 details

Site location	West Coorow
Species	TBC
Operation dates:	2022 clay spreading: 03/06/2022 2023 chicken manure spreading and ploughing
Plot area	50 m × 15 m
Seeder	16 m bar with knives and pressed wheels (25 cm between rows)
Soil amendments incorporating treatments	1. Control (Nil Clay) + Manure 2. 80 t/ha Bentonite Clay + Manure 3. 160 t/ha Bentonite Clay + Manure
Rotation	Nil, Wheat 2024

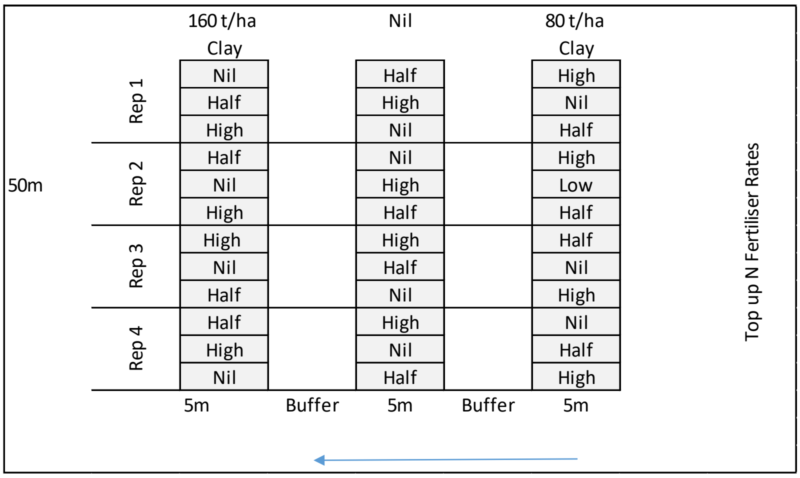


Figure 3. On-farm experiment (OFE) strip trial design. Nil had no nitrogen applied; Half received 100kg/ha of Nitrogen, and High received 200kg/ha of Nitrogen.

Table 1. Initial soil analyses at West Coorow including particle size analysis.

Depth	Gravel	Ammonium Nitrogen	Nitrate Nitrogen	Phosphorus Colwell	Potassium Colwell	Sulphur	Organic Carbon	pH Level (CaCl2)	PBI	% Clay	% Course Sand	% Fine Sand	% Sand	% Silt
	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%			%	%	%	%	%
0-10	0	1	< 1	7	25	1.6	0.24	5.1	6.7	5.73	81.64	12.62	94.26	< 0.01
10-30	0	< 1	< 1	4	24	1.7	0.15	5.1	6.0	3.95	87.94	7.10	95.04	1.00
30-50	0	< 1	< 1	2	17	1.1	0.08	5.5	11.4	5.81	74.13	18.11	92.24	1.95
50-70	0	< 1	< 1	5	22	0.8	0.06	5.7	8.6	5.92	76.42	17.65	94.07	< 0.01

Table 2. Chicken Manure Nutrient Analysis 2023 West Coorow site including particle size analysis.

Name	Depth	Compost EC 1:5	Compost pH 1:5	Compost Soluble NH4N	Compost Soluble NO3N	Compost Soluble PO4P
		dS/m		mg/kg	mg/kg	mg/kg
Chicken Manure	0-10	4.99	6.7	2379	29	1909
Chicken Manure	0-10	12.66	5.9	1431	3	831
Chicken Manure	0-10	11.57	6.0	1429	3	954
Chicken Manure	0-10	7.35	7.1	2352	56	1291

Table 3. Baseline Soil Carbon Results

Treatment number	Depth	Total organic carbon (acid wash) (oven-dried)	Total Organic Carbon (Acid Wash)	Moisture (air-dried)	Gravimetric Water Content
		%	%	%	
(T1)	0-10	0.46	0.46	< 0.5	< 0.005
(T1)	10-30	0.15	0.15	< 0.5	< 0.005
(T3)	0-10	0.50	0.50	< 0.5	< 0.005
(T3)	10-30	0.20	0.20	< 0.5	< 0.005
(T1)	0-10	0.55	0.55	< 0.5	< 0.005
(T1)	10-30	0.16	0.16	< 0.5	< 0.005
(T3)	0-10	0.48	0.48	< 0.5	< 0.005
(T3)	10-30	0.15	0.15	< 0.5	< 0.005
(T1)	0-10	0.33	0.33	< 0.5	< 0.005
(T1)	10-30	0.16	0.16	< 0.5	< 0.005
(T3)	0-10	0.41	0.41	< 0.5	< 0.005
(T3)	10-30	0.13	0.13	< 0.5	< 0.005
(T1)	0-10	0.43	0.43	< 0.5	< 0.005
(T1)	10-30	0.23	0.23	< 0.5	< 0.005
(T3)	0-10	0.41	0.41	< 0.5	< 0.005
(T3)	10-30	0.20	0.20	< 0.5	< 0.005

2024 Results

Trial Details

Trial Location	Wass Holdings West Coorow
Plot size & replication	50m x 15m x 3 replications
Soil type	Deep yellow coarse sand
Paddock rotation	2024 70 kg/ha Anvil Wheat
Inputs	80 kg/ha MAPMOP at seeding Half N Treatment: 100 N/ha High N Treatment: 200 N/ha

Treatments

Treatment No.	Treatment	Nitrogen strategy	Nitrogen (N/ha)
1	Control	Basal N	0
2		Half N	100
3		High N	200
4	80t/ha Bentonite Clay	Basal N	0
5		Half N	100
6		High N	200
7	160t/ha bentonite clay	Basal N	0
8		Half N	100
9		High N	200

2024 Rainfall

Growing season rainfall 2024 (May to October) 269 mm, long-term average 208.6mm.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0.0	12.2	7.7	22.6	9.8	91.7	84.0	56.5	9.6	17.4	14.4	6.8	332.7

Results

Harvest cuts were taken on the 31st of October. The collected samples were processed at the Liebe Group lab to evaluate grain weight, harvest index and protein.

Grain Weight

Grain weight was taken at maturity. While there was no significant difference between all treatments ($p>0.05$), there is a clear difference between clay levels ($p<0.05$) and visible trends in the data. The response of each clay treatment to Nitrogen is notable:

Nil Clay treatment: No response to increased nitrogen.

80 t/ha Clay treatment: Responded well to 100 units of N applied but didn't respond to 200 units of N. The 0 N treatment yielded 0.61 t/ha; the 100N on the 80 t/ha treatment yielded 0.84 t/ha. There was no response to the 200 units of N, with that treatment yielding an average of 0.56 t/ha.

160 t/ha Clay treatment: Responded consistently to higher levels of N, with yield averages of 0.83 t/ha for 0N, 0.94 t/ha for 100N, and 1.02 t/ha for 200N. This treatment also outperformed both Nil and 80 t/ha, which weren't significantly different from each other.

Overall, the 160 t/ha clay treatment gave the highest results, with the best yield and response to nitrogen. While there is a slight difference between Nil and 80 t/ha clay treatment, it was insignificant.

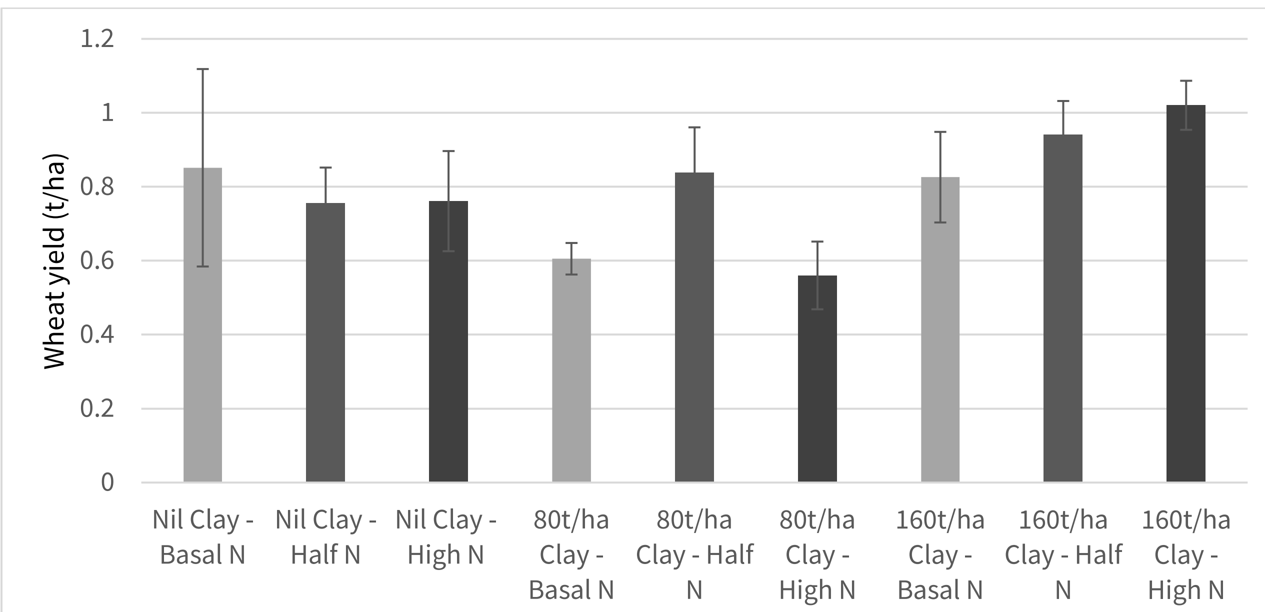


Figure 1. 2024 Wheat yield as affected by clay and nitrogen treatments. Vertical bars indicate the standard error of means.

Shoot Biomass

The shoot biomass was measured at maturity using harvest cuts. There is a difference in shoot biomass with increased clay content, although there is no trend in the data (Nil Clay: 2.4 t/ha, 80 t/ha Clay: 2 t/ha and 160 t/ha Clay: 2.6 t/ha) these results are not statistically significant ($p>0.05$). There was a significant difference between all treatments ($p<0.05$) caused by the N levels; higher N levels consistently resulted in greater shoot biomass (Basal N: 1.7 t/ha, Half N: 2.5 t/ha and High N: 2.7 t/ha). The greater N consistently resulted in a lower harvest index (reduced grain-to-chaff ratios). This indicates that water stress later in the season limited grain production with extra N.

Grain Protein

Grain protein content was not significantly influenced by the clay treatments but exhibited a clear positive trend in response to N treatments. Increased N consistently resulted in higher protein levels in the grain. In this trial, within the range of 0 to 200 units of N, protein content increased by an average of 0.47% for every additional 10 units of N, with a starting point of 10% protein for zero units of N.

Comments

This year, a wheat crop was sown at the trial site. Due to dry conditions in 2023, the site wasn't sown, making this the first year of cropping. While this paddock was previously unsuitable for cropping, this crop has benefited from the improved water-holding capacity and nutrients provided by the bentonite clay applied in 2022 and the chicken manure spread in 2023.

The crop was initially sown in April, but machinery issues at seeding resulted in uneven establishment; shortly after emergence, the crop was manually removed from the trial site, and the entire crop was resown on 03/05/2024. Unfortunately, the second sowing time did not perform well, resulting in very low yields.

The trends associated with N use efficiency in each clay treatment indicate that higher clay treatments resulted in the wheat crop better utilising available N, this may be due to better water holding capacity in the higher clay level treatments. However, further research will be required to confirm the reason for these results.

The addition of N increased the protein content; this is an expected result as N is a key component for amino acids. The increased N also resulted in the crop building greater biomass, reducing the harvest index. The clay treatments did not significantly affect the harvest index, shoot biomass or grain protein levels but did influence the yield positively.

These results indicate that the amount of clay has produced greater fluctuations in the crop yield than change in the amount of N (Figure 1). Thus, in the given conditions, changing the clay component of the soil may alone provide greater benefits than adding N-rich fertilisers. Noticeably, yield received from the clay applied at 80 t/ha is statistically not different than control (no clay). This implies that clay applied at a rate lower than 160 t/ha may not provide any yield benefits in the given conditions.

Conclusion

Results from 2024 confirm the positive effect of higher clay incorporation rates on crop performance at the West Coorow Carbon Demonstration site, with yield responses driven more by clay rate than nitrogen application. Nitrogen lifted biomass and protein levels but didn't translate into higher yields under the season's conditions.

Soil organic carbon testing in 2025 showed no significant differences between treatments at either depth, which was expected at this stage. Building measurable carbon in coarse-textured soils is a slow process and depends on consistent biomass return and organic matter cycling over multiple years.

Overall, higher clay rates appear to offer greater benefits for crop performance on these sandy soils than additional nitrogen fertiliser under the conditions experienced. While carbon stocks remain unchanged at this stage, the soil improvements from clay incorporation provide a foundation for potential long-term carbon gains.

Acknowledgements

Thank you to Charles Wass for hosting and implementing the trial and Watheroo Minerals for the supply of the bentonite clay. This project is part of the Western Australian Carbon Farming and Land Restoration Program, Future Carbon Scheme, funded by the Department of Primary Industries and Regional Development and led by the High Performance Soils Co-operative Research Centre.

References

Hoyle, F. C., Baldock, J. A., & Murphy, D. (2011). Soil organic carbon - role in rainfed farming systems. *Rainfed Farming Systems,* 339-361.

Hoyle, F. C., & Murphy, D. (2018). *Soil Quality: Soil Organic Matter.* Perth: SoilsWest.

Extension Activities

E-news article

R & D book article

Facebook post: (link in post)

Posts About Photos Events Mentions

The Liebe Group
26 Mar 2024 ·

Ploughing 160t/ha bentonite clay into a trial at Coorow. Looking at bringing an unproductive sand back into production, improve soil health and increase soil carbon. @Wantfa @SoilCRC

Read more (https://buff.ly/3Vo945b)